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Counter track joint with track turning point

Description

The invention relates to a constant velocity joint in the form of a counter track joint with the following characteristics:
an outer joint part which comprises a first longitudinal axis and an attaching end and an aperture end which are axially opposed relative to one another, and which outer joint part further comprises first outer ball tracks and second outer ball tracks;
an inner joint part which comprises a second longitudinal axis and attaching means for a shaft pointing to the aperture end of the outer joint part, and which inner joint part further comprises first inner ball tracks and second inner ball tracks;
the first outer ball tracks and the first inner ball tracks form first pairs of tracks with one another;
the second outer ball tracks and the second inner ball tracks form second pairs of tracks with one another;
the pairs of tracks each accommodate a torque transmitting ball ;
a ball cage is positioned between the outer joint part and the inner joint part and comprises circumferentially distributed cage windows which each accommodate at least one of the balls;
when the joint is in the aligned condition, the aperture angle of the first pairs of tracks opens in the central joint plane from the aperture end to the attaching end of the outer joint part;

when the joint is in the aligned condition, the aperture angle of the second pairs of tracks opens in the central joint plane from the attaching end to the aperture end of the outer joint part.

In principle, counter track joints of the above-mentioned type are known from DE 102 20 711 A1 showing joints with 6 balls and with 8 balls. The type of ball tracks described here corresponds to the type known in itself from Rzeppa joints (RF joints) and undercut-free joints (UF joints). This means that the centre lines of the ball tracks consist of uniform radii (RF joints) and, respectively, are composed of radii and adjoining axis-parallel straight lines (UF joints). In the counter track joints described, the axial opening direction of the pairs of tracks alternates around the circumference, which leads to the type of counter track joint. Counter track joints of this type are disadvantageous in that the angle of articulation is limited to approximately 45 degrees because when this angle of articulation is exceeded, the first ball in the joint articulation plane leaves the first pairs of track.

From DE 103 37 612 A1 there are known counter track joints wherein the track centre lines of the first pairs of tracks whose opening angle - when the joint is in the aligned condition - points towards the joint base, are designed in such a way that, when the joint is articulated, the opening angle, from a certain angle of articulation onwards, experiences a reversal of its direction of opening. More particularly, this is achieved in that the centre lines of the ball tracks of the first pairs of tracks are S-shaped and thus each comprise a turning point.

DE 100 60 220 A1, inter alia, describes counter track joints wherein the centre lines of the first outer ball tracks com-

prise a turning point near the joint aperture, so that the centre lines of the first outer ball tracks are S-shaped. Because of the requirement of symmetry, the same applies to the centre lines of the first inner ball tracks of the inner joint part. The angle of articulation of said counter track joints can be increased in this way.

As far as joints of the two latter types are concerned, the basic principle of counter track joints, i.e. alternately opposed directions of the track opening angles and thus alternately opposed directions of the axial forces of balls acting on the ball cage only applies until a ball has reached the turning point from the inwardly curved track region to the outwardly curved track region. When the angle of articulation at which the ball occupies said second track region of the respective S-shaped tracks has been reached, the track opening angles are no longer, in their entirety, alternately directed around the circumference and the axial forces applied by the balls to the ball cage are no longer axially balanced. The counter track principle thus no longer applies and the ball cage has to axially support itself at the outer joint part and/or on the ball hub. Because of the increased internal friction between the ball cage and the outer joint part and inner joint part respectively, this can lead to a reduced service life.

Based on this, it is the object of the present invention, starting from the state of the art mentioned initially, to develop a fixed joint ot the counter track type, which can achieve increased angles of articulation and features an increased service life.

The solution consists in providing a joint with the following characteristics:
an outer joint part which comprises a first longitudinal axis and an attaching end and an aperture end which are axially opposed relative to one another, and which outer joint part further comprises first outer ball tracks and second outer ball tracks;
an inner joint part which comprises a second longitudinal axis and attaching means for a shaft pointing to the aperture end of the outer joint part, and which inner joint part further comprises first inner ball tracks and second inner ball tracks;
the first outer ball tracks and the first inner ball tracks form first pairs of tracks with one another;
the second outer ball tracks and the second inner ball tracks form second pairs of tracks with one another; the pairs of tracks each accommodate a torque transmitting ball;
a ball cage is positioned between the outer joint part and the inner joint part and comprises circumferentially distributed cage windows which each accommodate at least one of the balls;
when the joint is in the aligned condition, the aperture angle of the first pairs of tracks opens in the central joint plane from the aperture end to the attaching end of the outer joint part;
when the joint is in the aligned condition, the aperture angle of the second pairs of tracks opens in the central joint plane from the attaching end to the aperture end of the outer joint part,
characterised in that the central track lines of the first pairs of tracks each have a turning point T_{1-2} and that the centre angle β at the turning point, with reference to the central joint plane, is greater than 4°. In this way it is ensured that, within the service life range of operation, the

joint operates as a counter track joint. The service life range of operation refers to joint operation within the service life angle at which the design service life of the joint is reached under changing load conditions without the joint suffering any damage.

This means that within the so-called service life range, the principle of the counter track joint always applies, so that the service life is prolonged. The service life range is defined by the service life angle β_L. If operated within this angle of articulation, the joint, by definition, reaches the design service life. At the same time, however, a further joint articulation is possible so that greater angles of articulation can be achieved. In accordance with the invention, the transition to the second range is defined in such a way that it is located outside the track region which is passed by the balls in the service life range in the ball tracks. Below, preferred embodiments will be described for the position of said turning point. It has to be explained here how the term "turning point" is used: on the one hand, in the mathematically applicable sense of a transition from a curvature into a counter-curvature and on the other hand, in a mathematically inaccurate sense for the transition from a curvature into a straight line tangentially adjoining the curvature. Both interpretations apply to the term "turning point" used here. It would also be possible to use the term "tangent point".

According to a first preferred embodiment, it is proposed that that the centre angle β at the turning point P_{1-2}, with reference to the central joint plane E, is greater than 5°. According to a further embodiment, it is proposed that the centre angle β at the turning point P_{1-2}, with reference to the central joint plane E, is smaller than 12°.

Furthermore, it is proposed that a tangent T_{1-2} at the central track line of the first pairs of tracks in the turning point P_{1-2} forms a turning point angle α, with the respective longitudinal axis and, respectively, that a perpendicular line on said tangent T_{1-2} forms a turning point angle α with the central joint plane (E), which turning point angle is defined by

$$\alpha \geq \beta + \arcsin\left[\frac{O_2}{R_2} \cdot \sin\left(\beta + 90^\circ\right)\right]$$

wherein O_2 is the axial distance between the point of intersection of a perpendicular line on the tangent T_{1-2} and the respective longitudinal axis A and wherein R2 is the distance between said point of intersection and the turning point P_{1-2}.

According to a further first special embodiment it is proposed that the turning point angle α is defined by

$$\alpha \geq \beta + \arcsin\left[\frac{O_2 + a \cdot \tan\left(\beta\right)}{R_2} \cdot \sin\left(\beta + 90^\circ\right)\right]$$

if the respective track centre lines in the central joint plane E and up to the turning point P_{1-2} comprise a radius R_2 whose centre M_2 comprises an axial distance O_2 from the central joint plane E and a radial distance a from the respective longitudinal axis in the direction towards the turning point P_{1-2}.

An alternative special embodiment consists in that the turning point angle α is defined by

$$\alpha \geq \beta + \arcsin\left[\frac{O_2 - b \cdot \tan\left(\beta\right)}{R_2} \cdot \sin\left(\beta + 90^\circ\right)\right]$$

if the respective track centre line in the central joint plane E and up to the turning point P_{1-2} comprise a radius R_2 whose centre M_2 comprises an axial distance O_2 from the central joint plane E and a radial distance b from the respective longitudinal axis A in the direction away from the turning point P_{1-2}.

An inventive counter track joint with 8 balls for an angle of articulation of 47 - 52° is optimised if the following relationships are observed between individual measured parameters:

1/5	< PCDB /	R1	< 1.9
1.8	< PCDB /	R2	< 2.2
2.3	< PCDB /	R3	< 2.7
2.1	< PCDB /	R4	< 2.5
1.8	< PCDB /	R5	< 2.2
12	< PCDB /	O2	< 16
12	< PCDB /	O5	< 16
0.6	< PCDB /	OD	< 0.8
2.1	< PCDB /	L	< 2.5
3.4	< PCDB /	DB	< 4.0
2.1	< PCDB /	DS	< 2.5
0.75	< PCDB /	DCA	< 1.05
0.85	< PCDB /	DCI	< 1.15
7.5	< PCDB /	W	< 11.5
2.8	< PCDB /	L1	< 3.4
2.6	< PCDB /	L2	< 3.2

In said relationships, the parameters used have the following meaning:

PCDB: pitch circle diameter of balls
R1 : outer part ball track radius 1 (first ball tracks)

R2 : outer part ball track radius 2 (first ball tracks)
R3 : outer part ball track radius 3 (first ball tracks)
R4 : outer part ball track radius 4 (second ball tracks)
R5 : outer part ball track radius 5 (second ball tracks)
O2 : outer part ball track offset for track with opening angle towards attaching end
O5 : outer part ball track offset for track with opening angle towards aperture end
OD : outer diameter outer part
L : length inner part
DB : ball diameter
PCDS: pitch circle diameter of splines
DCA : cage outer diameter
DCI : cage inner diameter
W : cage web width
L1 : cage window length 1
L2 : cage window length 2.

Preferred embodiments of the invention are illustrated in the drawings and will be described below:

Figure 1 shows an inventive counter track joint with 6 balls in a first embodiment

a) in a complete view in a longitudinal section
b) with its outer joint part in the form of a detail in a longitudinal section.

Figure 2 shows a counter track joint with 6 balls according to Figure 1

a) in a longitudinal section with dimensional specifications
b) in a longitudinal section with further dimensional specifications
c) the ball cage as a detail in a developed view.

Figure 3 shows a counter track joint with 8 balls similar to that shown in Figures 1 and 2

a) with dimensions in a longitudinal section
b) in an angled position with further dimensional specifications
c) the ball cage as a detail in a developed view.

Figure 4 shows an inventive joint with 6 balls in a second embodiment

a) in a complete view in a longitudinal section
b) the outer joint part as a detail in a longitudinal section
c) the inner joint part as a detail in a longitudinal section.

Figure 5 shows the outer joint part of an inventive joint according to Figure 4 with further dimensional specifications in a longitudinal section.

Figure 6 shows the inventive joint according to Figures 4 and 5 with further dimensional specifications

a) in a longitudinal section through the outer joint part
b) in a cross-section through the ball tracks
c) an evaluation table.

Figure 7 shows the outer joint part of an inventive joint in a further embodiment in a longitudinal section with dimensional specifications.

Figure 8 shows the outer joint part of an inventive joint in a further embodiment in a longitudinal section with dimensional specifications.

Figure 9 shows an inventive 6-ball counter track joint with a definition of the counter tracks

a) in an axial view

b) in a longitudinal section.

Figure 10 shows an inventive 6-ball counter track joint with a definition of the counter tracks

a) in an axial view

b) in a longitudinal section.

Figure 11 shows an inventive 6-ball counter track joint with a definition of the counter tracks

a) in an axial view

b) in a longitudinal section

Figure 12 shows an inventive 6-ball counter track joint with a definition of the tracks

a) in an axial view

b) in a longitudinal section through the joint (RF track).

Figure 13 shows an inventive 8-ball counter track joint with a definition of the counter tracks

a) in an axial view

b) in a first longitudinal section

c) in a second longitudinal section

Figure 14 shows an inventive 8-ball counter track joint

a) in an axial view

b) in a first longitudinal section

c) in a second longitudinal section

Figure 15 shows an inventive 8-ball counter track joint

a) in an axial view

b) in a first longitudinal section

c) in a second longitudinal section

Figure 16 shows an inventive 8-ball counter track joint

a) in an axial view

b) in a first longitudinal section

c) in a second longitudinal section.

Figure 17 shows an inventive 6-ball counter track joint with a definition of the tracks and with further details

a) the outer joint part in a longitudinal section

b) an outer track in a longitudinal section

c) the inner joint part in a longitudinal section

d) an inner track in a longitudinal section

e) an evaluation table.

Figure 18 shows an inventive 8-ball counter track joint similar to that shown in Figure 13, with a definition of individual parameters

a) in an axial view

b) in a first longitudinal section

c) in a second longitudinal section

d) in a cross-section through the ball cage.

Figure 19 shows an inventive 8-ball counter track joint similar to that shown in Figure 13 with a definition of the tracks

a) in an axial view

b) in a longitudinal section through the outer joint part

c) in a longitudinal section through the ball cage.

Figure 20 shows an inventive driveshaft as incorporated into a motor vehicle in a partial longitudinal section.

The two illustrations of Figure 1 will be described jointly below. An inventive constant velocity joint 11 comprises an

outer joint part 12 with an aperture 25 with a closed base 13 and an integrally attached journal 14. Furthermore, the joint comprises an inner joint part 15, a ball cage 16 as well as torque transmitting balls 17. First outer ball tracks 18 and first inner ball tracks 19 accommodate balls 17_1 and form first pairs of tracks with one another. Second outer ball tracks 20 and second inner ball tracks 21 form second pairs of tracks which receive second balls 17_2. The two types of pairs of tracks are alternately arranged around the circumference. Tangents at the balls in the points of contact with the first pairs of tracks which are shown in the drawing, together, form an opening angle δ_1 which opens in the direction towards the base 13. Tangents at the second balls 17_2 in the points of contact with the second pairs of tracks, together, from an opening angle δ_2 which opens towards the aperture 21 of the outer joint part. When the joint is in the aligned condition and subjected to torque, said opening angles generate axial forces referred to as F_1 and F_2 and apply those to the balls and thus to the ball cage 16. A central joint plane E which receives the centres of the balls intersects the longitudinal axis of the joint in a joint centre M, which longitudinal axis of the joint is defined by the longitudinal axis A_{12} of the outer joint part and by the longitudinal axis A_{22} of the inner joint part. With reference to the centre lines L_{18} of the ball tracks 18 in the outer joint part 12, the tracks 18 in the central plane comprise a radius R_2 whose centre is offset by an axial offset O_2 on the axis A relative to the joint centre M, whereas the tracks 20 comprise an identically sized radius R_5 whose centre is offset by an offset O_5 in the opposite direction relative to the joint centre M.

In Figure 2, any details identical to those shown in Figure 1 have been given the same reference numbers. In illustration a), a shaft 22 is inserted into the inner joint part 15. In

addition to the longitudinal axis A_{12} of the outer joint part, there is shown the longitudinal axis A_{22} of the inner joint part which, in the same way, corresponds to the longitudinal axis of the inner joint part 15. With reference to the longitudinal axis A_{22}, service life angles 2β are given on both sides; they indicate the maximum angle of articulation at which the joint can be operated without suffering any damage in the service life test. The service life test is meant to refer to a load spectrum which corresponds to the practical use of a joint in the course of the design service life. When the shaft 22 is articulated relative to the outer joint part 12 at the angle 2β on both sides each, the balls 17_1 in the inventive ball tracks 18, 19 carry out movements along the track centre line, which movements are defined by the angle β on both sides each from the central joint plane E, wherein the legs of the angle are formed by the central joint plane E and by rays through the ball centre. Illustration c) shows the ball cage 16 in a developed view with three circumferentially distributed cage windows 23, 24. Balls 17_1 held in first pairs of tracks apply an axial force F_1 to the ball cage and balls 17_2 held in second pairs of tracks apply an axial force F_2 to the ball cage. Because of the alternating arrangement of first and second pairs of tracks, even when transmitting torque across via the joint, is axially balanced.

In illustration a) of Figure 3, with reference to the longitudinal A_{22} of the shaft 22, there is shown on both sides each - in addition to the service life angle 2β - the maximum articulation angle β_{max}. Accordingly, with reference to the position of the ball centre relative to the outer joint part, there are again shown half the service life angles β as well half the maximum articulation angles $\beta_{max/2}$ on both sides, starting from the central plane E. The ball positions in the outer joint part at the maximum articulation angle β_{max} are shown in dashed

lines.

Illustration b) shows the maximum articulation angle at the joint in a direction in which the balls 17_1 move in the inventive pairs of tracks 18, 19 towards the aperture 21 of the outer joint part 12. Because of the S-shaped course followed by the inventive ball tracks 18, 19, the opening angle δ_1 between the tangents at the balls 17_1 in the first pairs of tracks has reversed its direction and also opens towards the aperture end 21 of the outer joint part 12, whereas the second pairs of tracks with tracks 20, 21 of the Rzeppa joint type form an opening angle δ_2 whose size, admittedly, changes, but which, as in the aligned joint position according to Figure 2, continues to open towards the aperture end 21 of the outer joint part 12. The directions of the forces F_1, F_2 acting on the balls in the sectional plane correspond to the opening angles δ_1, δ_2. As can be seen in illustration d), all the ball forces, in respect of their effect, correspond to one another as regards their direction, even if not in respect of size, so that a counter force F_G for against the sum of the ball forces acting on the cage has to be applied by the outer joint part to the cage. In accordance with the invention, such a counter force F_G occurs only if the service life angle 2β is exceeded, while inside the service life angle 2β the cage remains axially balanced.

Figure 4, in greater detail, shows a possible course which can be taken by the track centre lines L_{18}, L_{19} of the outer joint part and of the inner joint part for the inventive ball tracks 18, 19 according to a first embodiment. The inventive ball tracks whose course is represented by track centre lines L_{18}, L_{19} are S-shaped, and the figure also shows the position of the turning point T_{1-2} which, starting from a radius R_2 (outer joint part) and, respectively, $R_{2'}$ (inner joint part) is laid around

an offset point O_2 and $O_{2'}$ respectively, is positioned at an angle α relative to a radial plane, i.e. a plane extending parallel to the central joint plane E. Beyond the turning point T_{1-2}, the track centre line continues in a radius R_1 (outer joint part), and respectively, $R_{1'}$ itself. In accordance with the invention, the turning point T_{1-2} as well as the turning point $T_{1-2'}$ are positioned outside the angle sector of the angle $\beta_{L/2}$ as viewed on each side of the central joint plane E. As the reversal of the direction of the angle δ_1, upon the turning point T_{1-2} being exceeded, takes place in the first pairs of tracks, the requirement as specified here ensures that, in the service life range (articulation of A_{22} relative to $A_{12} < = 2\beta$ on both sides each) no axial forces occur at the cage, but that the cage is kept free from axial forces in the outer joint part.

Whereas the service life angle 2β is a centre angle with reference to the joint centre M - i.e. it starts from the longitudinal axis A_{12} and the central plane E respectively and, in this way, describes the position of a ball on the track centre line L_{18}, L_{19} - the centre of the angle α at the tangent at the track centre line in the turning point T_{1-2} features an offset O_2 and $O_{2'}$ respectively relative to the joint centre M.

Figure 5 shows the relationship between the service life angle β with reference to the travel of the ball along the track centre line L_{18} in the outer joint part relative to the turning point angle α, with the

$$\alpha \geq \beta + \arcsin\left[\frac{O_2}{R_2} \cdot \sin\left(\beta + 90^\circ\right)\right]$$

being applicable.

Figure 6, with reference to an outer joint part 12 according to Figure 5, shows the influence of the turning point angle α on the track enveloping angle ε in the outer joint part. The track enveloping angle ε is defined as the angle between a radial plane R and a ray through the ball centre and, respectively, the track centre line L_{18} at a track edge. When the track enveloping angle ε becomes small, there occur disadvantageous edge loads in the tracks 18, which edge loads can lead to damage. The torque transmitting capacity is thus limited. Up to a turning point angle α of 16° the track enveloping angle ε is still sufficiently large.

Figure 7 shows the relationship between the service life angle with reference to the travel of the ball in the track (β) and the turning point angle α for a second possible embodiment of an inventive outer joint part. In the region around the central joint plane E, the centre line L_{18} of the ball track 18 comprises a smaller radius R_2 with a centre M_2 which, relative to the joint centre M, is offset by an axial offset O_2 and by a radial offset a. The tangent at the turning point T_{1-2} is defined via said angle. From the turning point, the track centre line continues with a radius R_1 around a centre M_1 which is determined by the value of R_1 and by the value of the angle α. Between the service life angle β entered around the joint centre M and the turning point angle α, there applies the equation

$$\alpha \geq \beta + \arcsin\left[\frac{O_2 + a \cdot \tan(\beta)}{R_2} \cdot \sin(\beta + 90°)\right]$$

Figure 8 shows the relationship between the service life angle with reference to the travel of the ball in the track (β) and the turning point angle α for a second possible embodiment of

an inventive outer joint part. In the region around the central joint plane E, the centre line L_{18} of the ball track 18 comprises a smaller radius R_2 with a centre M_2 which, relative to the joint centre M, is offset by an axial offset O_2 and by a radial offset b. The tangent at the turning point T_{1-2} is defined via said angle. From the turning point, the track centre line continues with a radius R_1 around a centre M_1 which is determined by the value of R_1 and by the value of the angle α. Between the service life angle β entered around the joint centre M and the turning point angle α, there applies the equation

$$\alpha \geq \beta + \arcsin\left[\frac{O_2 - b \cdot \tan(\beta)}{R_2} \cdot \sin(\beta + 90°)\right]$$

Figure 9 shows an inventive 6-ball joint wherein the centre lines L_{18} of the outer ball tracks 18 are composed of three radii R_1, R_2, R_3, with the radii R_1, R_2 adjoining one another via a turning point, whereas the centre lines L_{20} of the second outer ball tracks 20 are defined by a radius R_5 with an adjoining axis-parallel straight line.

Figure 10 shows an inventive 6-ball joint wherein the centre lines L_{18} of the outer ball tracks 18 are composed of three radii R_1, R_2, R_3, with the radii R_1, R_2 adjoining one another via a turning point, whereas the centre lines L_{20} of the second outer ball tracks 20 are defined by two radii R_4, R_5 which adjoin one another via a turning point.

Figure 11 shows an inventive 6-ball joint wherein the centre lines L_{18} of the outer ball tracks 18 are composed of three radii R_1, R_2, R_3, with the radii R_1, R_2 adjoining one another via a turning point, whereas the centre lines L_{20} of the second outer

ball tracks 20 are defined by a radius R_5. The second tracks are thus of the same type as the tracks of RF joints.

Figure 12 shows an inventive 6-ball joint wherein the centre lines L_{18} of the outer ball tracks 18 are composed of two radii R_2, R_3 and a straight line tangentially adjoining the radius R_2 in the direction towards the aperture, whereas the centre lines L_{20} of the second outer ball tracks 20 are defined by a radius R_5.

Figure 13 shows an inventive 8-ball joint wherein the centre lines L_{18} of the outer ball tracks 18 are composed of three radii R_1, R_2, R_3, wherein the radii R_1, R_2 adjoin one another via a turning point, whereas the centre lines L_{20} of the second outer ball tracks 20 are defined by a radius R_5 with an adjoining axis-parallel straight line.

Figure 14 shows an inventive 8-ball joint wherein the centre lines L_{18} of the outer ball tracks 18 are composed of three radii R_1, R_2, R_3, wherein the radii R_1, R_2 adjoin one another via a turning point, whereas the centre lines L_{20} of the second outer ball tracks 20 are defined by two radii R_4, R_5 which adjoin one another via a turning point.

Figure 15 shows an inventive 8-ball joint wherein the centre lines L_{18} of the outer ball tracks 18 are composed of three radii R_1, R_2, R_3, wherein the radii R_1, R_2 adjoin one another via a turning point, whereas the centre lines L_{20} of the second outer ball tracks 20 are defined by a radius R_5. The second tracks are thus of the same type as the tracks of RF joints.

Figure 16 shows an inventive 8-ball joint wherein the centre lines of the outer ball tracks 18 are composed of two radii R_2, R_3 and a straight line tangentially adjoining the radius R_2 in

the direction towards the aperture, whereas the centre lines L_{20} of the second outer ball tracks 20 are defined by a radius R_5.

Figure 17 shows in detail the shape of the first outer ball tracks and of the first inner ball tracks for a 6-ball counter track joint according to Figure 1, with the centre line L_{18} of the first outer ball track 18 being composed of two radii R_1, R_2, as already described above, and with the centre line L_{19} of the inner ball track 19 consisting of two radii $R_{1'}$, $R_{2'}$ which are symmetrical relative to the joint centre M. In addition, the Figure shows, in the form of a table, the relationship between the turning point angle α and the track enveloping angle ε for the track 18 in the outer joint part and the track enveloping angle ε' for the track 19 in the inner joint part. This shows that it is necessary for $\alpha >= 10°$ and $<= 18°$ to be able to ensure satisfactory enveloping angles ε, ε'.

Figure 18 shows an inventive 8-ball joint which corresponds to that shown in Figure 13, with the ball cage 16 additionally being shown in the form of a detail in the cross-sectional view. Furthermore, it can be seen that the cage windows 13 for the first balls 17_1 comprise a shorter circumferential length L_1 than the cage windows 24 for the second balls 17_2 which comprise a longer circumferential length L_2. The outer ball cage diameter has been given the reference symbol DCA and the inner cage diameter the reference symbol DCI, in both cases with reference to the central plane E in which the ball cage is shown in section. The circumferential width of the cage webs, on the outside, has been given the reference symbol W. The pitch circle radius of the balls in the joint is referred to as PCDE, whereas the insertion aperture for the shaft in the inner joint part comprises a diameter PCDS. In case the connection between the inner joint part 15 and the shaft 22 is produced

produced via shaft teeth, said diameter PCDS equals the mean teeth diameter of the shaft teeth in the inner joint part.

Figure 19, which refers to an 8-ball joint, shows the track centre lines at the outer joint part and at the inner joint part separately. The first outer tracks 18 are composed of the three above-mentioned radii R_1, R_2, R_3, whereas the track centre line of the first inner ball track consists of three identically sized radii $R_{1'}$, $R_{2'}$, $R_{3'}$ positioned symmetrically relative thereto. The two outer ball tracks are composed of the radii R_4 and R_5 , whereas the corresponding second inner ball tracks 21, with reference to the joint centre M, comprise radii R_4', $R_{5'}$ arranged symmetrically relative thereto. The greatest outer diameter of the outer joint part is referred to as OD and the axial length of the inner joint part as L.

Figure 20 shows a driveshaft incorporated as a sideshaft into a motor vehicle. The figure shows an inventive driveshaft comprising an inventive constant velocity joint 11 in the form of a monoblock joint, furthermore an intermediate shaft 35 and a second constant velocity joint 31 which can also be an inventive joint, more particularly designed identically to the joint 11. The intermediate shaft 35 comprises an axial displacement unit 28 which, as major components, comprises a sleeve 29, a journal 30 and torque transmitting balls operating between the sleeve 29 and the journal 30, but which is not shown in greater detail and which permits an adjustment in the length of the driveshaft between the constant velocity joints 11, 31. The shaft journal of the inventive joint 11 has been inserted into a differential drive 32 and is secured therein, whereas the shaft journal of the second fixed joint 31 has been inserted into a wheel hub assembly 33 with a wheel bearing 34.

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Counter track joint with track turning point

List of reference numbers

11	constant velocity joint
12	outer joint part
13	base
14	journal
15	inner joint part
16	ball cage
17	ball
18	first outer track
19	first inner track
20	second outer track
21	second inner track
22	shaft
23	cage window
24	cage window
25	joint aperture

β_{max}	maximum joint articulation angle
β	service life angle
δ	opening angle
α	turning point angle
T_{1-2}	turning point
L	centre line
A	longitudinal axis
R	radius
E	central plane
M	joint centre
O	axial offset
A	radial offset
b	radial offset